1.0 Introduction

1.1 Purpose and Organization

This focused Bunker Hill Mine Water Management Remedial Investigation and Feasibility Study (RI/FS) identifies and evaluates remedial alternatives in accordance with the requirements of the National Contingency Plan (NCP), Part 300.430(f)(4)(ii) of the Code of Federal Regulations (CFR). It addresses the discharge of acid mine drainage (AMD) from the Bunker Hill Mine, located within the Bunker Hill Mining and Metallurgical Superfund Site near Kellogg, Idaho (see Figure 2-1 in Section 2 of this report).

This report consists of six sections:

Section 1, Introduction: Describes the purpose and organization of the RI/FS, provides introductory background and framework, summarizes the nature and extent of the AMD contamination, provides a definition of the problem, and lists the RI/FS goals and objectives.

Section 2, Characterization of the Site: Provides RI information, which includes background information, a summary of historical investigations and research, site characterization, the risk assessment, and applicable or relevant and appropriate requirements (ARARs).

Section 3, Identification and Screening of Technologies: Identifies and describes six remedy components and provides screening of technology options for each.

Section 4, Development of Alternatives: Develops and describes five alternatives for long-term management of the AMD.

Section 5, Detailed Evaluation of Alternatives: Evaluates the alternatives against the nine criteria required by the NCP.

Section 6, Works Cited: Lists the references used in the document.

This focused RI/FS was prepared using historical site-specific data and experience gained at other similar sites to streamline new data collection and remedial technology identification and screening. Historical information is summarized and referenced to augment the information presented in this report.

1.2 Background and Framework of This RI/FS

This RI/FS focuses on the AMD that discharges from the Kellogg Tunnel of the Bunker Hill Mine, which is located within the Bunker Hill Superfund site. The following text describes the relationship of this RI/FS with past and ongoing Superfund activities.

The Bunker Hill facility was placed on the National Priorities List (NPL) in 1983, pursuant to the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), Section 121(c), as amended. The Bunker Hill facility includes the area commonly referred to as the Bunker Hill Superfund site (BHSS). Soils, surface water, groundwater, and air within the site have been affected by contamination associated with metals mining and refining and related activities both up-gradient and within the site. Initial investigatory and cleanup actions at the facility were focused within the BHSS. This area was identified as having the most significant human health impacts.

The facility has been divided into four cleanup areas, which are also called operable units (OUs). The four operable units are: the populated areas (OU 1); the non-populated areas (OU 2); the long-term management of AMD from the Bunker Hill Mine (OU3); and mining-related contamination in the broader Coeur d’Alene River Basin (OU 4). A Record of Decision (ROD) for the populated areas was signed in 1991 (EPA, 1991). A ROD for the non-populated areas was signed in 1992 (EPA, 1992). In 1998, a RI/FS of the third OU was initiated to address the long-term management of AMD from the Bunker Hill Mine, which is the subject of this document. Also in 1998, EPA initiated a RI/FS of the fourth OU to address mining-related contamination in the greater Coeur d’Alene River Basin. A summary of the four operable units is provided below.

1.2.1 Operable Unit 1

The populated area of the BHSS (OU 1) includes residential and commercial properties, rights-of-way (ROWs), and public use areas in the towns of Kellogg, Wardner, Smelterville, Pinehurst, and several smaller unincorporated communities. Cleanup activities began in this OU because this was the area of greatest concern for human health exposure. In 1985, a Lead Health Intervention Program (LHIP) was initiated by the Centers for Disease Control (CDC) and the Agency for Toxic Substances and Disease Registry (ATSDR) to minimize blood lead levels in children through health education, parental awareness, and biological monitoring. The program is ongoing to date and is administered by the local Panhandle Health District under the Idaho Department of Health and Welfare.

In 1986, some city parks and school playgrounds were cleaned up as part of a CERCLA removal action. The yard soil removal program was initiated in 1989 as a CERCLA time-critical removal action to replace contaminated soils in yards of homes where young children at highest risk of lead poisoning lived. Since 1994, the yard soil removal program has been implemented by the potentially responsible parties (PRPs) pursuant to the 1991 populated area ROD. The PRPs are scheduled to remediate 200 residential parcels each year until all yards, commercial properties, and ROWs with lead-contaminated soils greater than or equal to 1,000 parts per million (ppm) have been remediated to achieve a community-wide average of 350 ppm lead. Completion of remedial activities in the populated area is expected by 2003.

House dust, long recognized as a primary source of lead exposure to children, is being monitored through the LHIP. If house dust lead levels remain elevated following completion of remediation, homes with dust lead concentrations greater that 1,000 ppm will be evaluated for interior remediation. A Five-Year Review of OU1 was completed in 2000. The review document further describes OU1 cleanup activities (EPA, 2000a).

1.2.2 Operable Unit 2

The non-populated area operable unit of the BHSS (OU 2) includes the former industrial complex and mine operations area, river flood plain, hillsides, various creeks and gulches, site surface water and groundwater, and the Central Impoundment Area (CIA). Site PRPs performed various removal activities pursuant to several orders prior to the 1992 ROD, including smelter stabilization efforts from 1989 to 1993, and hillside revegetation and fugitive dust control efforts from 1990 to 1992.

Following completion of the ROD in 1992, five PRPs signed a Consent Decree with the U.S. Environmental Protection Agency (EPA) to perform cleanup activities in limited areas of the site, including the Union Pacific Railroad ROW, the A-4 gypsum pond, and the Page Pond tailings repository. In 1995, EPA and the State of Idaho entered into a State Superfund Contract to perform the remaining site remedial actions. Cleanup actions addressed in the ROD included a series of source removals, surface capping, reconstruction of surface water creeks, demolition of abandoned milling and processing facilities, engineered closures for waste consolidated on site, revegetation efforts, and surface water and groundwater controls and treatment in a constructed wetlands treatment system. There has been one ROD amendment (EPA, 1996) and two Explanations of Significant Differences since the ROD was completed in 1992. A Five-Year Review of OU2 was completed in 2000. The review document further describes OU2 cleanup activities (EPA, 2000b).

In the State Superfund Contract, EPA and the State of Idaho agreed to a two-phased site implementation strategy. Phase I largely addresses source removals aimed at consolidating extensive contamination from various areas of the site. Phase I cleanup activities are estimated to be substantially completed in 2001. Phase II will address site surface water and groundwater cleanup and will be implemented following completion of source control and removal activities and evaluation of the effectiveness of these activities in meeting water quality improvement objectives.

Although Phase II water quality-related cleanup has not yet begun, a laboratory bench study was conducted by the U.S. Bureau of Mines. That study demonstrates that a technical approach for treatment using a wetlands treatment process is not able, on a year-round basis, to achieve the desired water quality. These bench-scale laboratory studies were performed to test this treatment process on contaminated surface water and groundwater, and on Bunker Hill mine water (U.S. Bureau of Mines, 1998).

1.2.3 Operable Unit 3

At the time the non-populated areas ROD was written in 1992, the Central Treatment Plant (CTP), which was built by the Bunker Hill Company in 1974 to treat the mine water and other industrial complex wastewaters, was under private ownership and was anticipated to remain so. Therefore, the 1992 ROD did not address control of AMD from the Bunker Hill Mine or operation of the CTP in any significant way. It briefly addressed the mine water by requiring that it continue to be treated in the CTP prior to discharge to a wetlands treatment system for removal of residual metals. However, the wetlands treatment system, as noted above, was found by the U.S. Bureau of Mines to be unreliable on a year-round basis.

The 1992 ROD did not contain or otherwise identify any plans for the control or long-term management of the mine water. Subsequent to the 1992 ROD, some measures were taken to

NEXT

reduce mine water flows. Between December 1994 and February 1995 the New Bunker Hill Mining Company (the current mine owner/operator) plugged 72 drill holes within the mine that were discharging water. They also placed a concrete bottom in the reservoir behind the Bunker Hill Dam in mainstem Milo Creek. This was done to reduce leakage to underlying mine workings. In 1998 and 1999 a water diversion project was implemented on the mainstem of Milo Creek. The purpose of the project was to minimize contact between Milo Creek surface water and tailings/waste rock on the valley floor, and to reduce infiltration into the mine workings underlying that stretch of Milo Creek. Although, to date, the effectiveness of these measures to reduce infiltration cannot be determined, it is believed that AMD flows, and particularly the seasonal peak flows, can be significantly reduced by additional measures.

The 1992 ROD also did not address the long-term management of the treatment residuals (sludge) from the CTP, which are currently pumped into an unlined pond on the CIA. At current disposal rates it is estimated that this pond will be filled in 3 to 5 years. In addition, the 1992 ROD acknowledged that development of a total maximum daily load (TMDL) for the South Fork Coeur d'Alene (SFCdA) River, as required by the Clean Water Act (CWA), was being considered. At the time of the 1992 ROD, however, the TMDL was not developed.

In September 1996, the United States District Court for the Western District of Washington ordered EPA and the State of Idaho to develop a schedule for completion of TMDLs for all water quality impaired streams earlier identified by the state, including the Coeur d'Alene River Basin (Basin). TMDL development for the Basin was initiated in 1998. In August 2000, a TMDL for dissolved cadmium, lead, and zinc in surface waters of the Basin was jointly released by EPA and the State of Idaho. These metals were considered the highest priority for TMDL development because large portions of the Basin exceed the water quality standards for these metals. The TMDL assigned individual wasteload allocations to approximately 70 discrete sources, including the Bunker Hill CTP, that contribute metals to surface waters of the Coeur d'Alene River and its tributaries.

In February 1998, EPA and the Idaho Department of Environmental Quality (IDEQ) released a jointly prepared memorandum that described additional considerations for the long-term management of the Bunker Hill mine water (IDEQ and EPA, 1998). The joint memorandum identified the need to begin further evaluations for long-term mine water management, including achievement of the TMDL and long-term sludge disposal. With this memorandum, IDEQ and EPA jointly initiated the RI/FS process for OU3, and in response, the Bunker Hill Mine Water Management RI/FS was begun in August 1998. A joint work group including representatives from EPA, IDEQ, contractors for both agencies, and the New Bunker Hill Mining Company (NBHMC) have worked together in developing the RI/FS.

1.2.4 Operable Unit 4

At the time the 1992 non-populated areas ROD was written, it was widely recognized that mining-related contamination in North Idaho was not limited to the areas surrounding the BHSS. Actions selected in the ROD did not address sources of contamination upgradient of the site, and although selected actions were expected to have significant benefits over time to down-gradient SFCdA River water quality, active remediation of the SFCdA River was beyond the scope of the ROD. To address these and other contamination and water quality issues in the broader Coeur d'Alene Basin, the EPA, State of Idaho, the Coeur d'Alene Tribe, and other federal, state, and local agencies formed the Coeur d'Alene Basin Restoration Project. The purpose of this project was to integrate water quality improvement programs in the Basin through coordination of the federal regulatory authorities under the CWA, CERCLA, and RCRA, and other state, local, and tribal programs.

In 1998, EPA began to look more closely at broader Basin-wide contamination issues and initiated a RI/FS for the Coeur d'Alene Basin. The Basin, as evaluated in the RI/FS, includes the watershed and flood plains and associated communities of the South Fork, North Fork, and Main Stem of the Coeur d'Alene River, Coeur d'Alene Lake, and the Spokane River that drains from Coeur d'Alene Lake and crosses from Idaho into Washington State. The TMDL, discussed above, establishes water quality-based targets for the RI/FS for cadmium, lead, and zinc in the Coeur d'Alene River and its tributaries.

The BHSS, including the Bunker Hill Mine, is located within the area being investigated as part of the Basin project. The remedial actions conducted within the non-populated areas of the site are being reviewed and considered in the Basin RI/FS process. For example, an evaluation of metals loading from all sources in the Basin, including the non-populated areas (OU 2), is included in the Basin RI/FS. It is possible that additional cleanup actions in the non-populated area may need to be considered if determined necessary to meet overall cleanup goals for the Basin. It also possible that cleanup technologies and strategies being considered for the Bunker Hill mine water, such as water treatment and sludge management, may be similar or compatible with those considered for the Basin. This overlap may provide opportunities that benefit cleanup in both OUs.

1.3 Bunker Hill Mine Water

The preceding section described the relationship of the Bunker Hill Mine Water OU (OU3) to the other three related OUs within the Coeur d'Alene Basin. This section provides an overview of the mine water and the current mine water management system. Additional mine water characterization is provided in Section 2.

1.3.1 Mine Water Characteristics

The AMD is a result of acid-forming reactions occurring within the mine between water, oxygen, sulfide minerals and bacteria. The majority of the AMD is formed within the Flood-Stanly Ore Body. Yearly spring snowmelt cycles typically increase water infiltration through the ore body, which in turn increases AMD formation. The largest area of water infiltration to the Flood-Stanly Ore Body is the West Fork Milo Creek Basin, where all the creek flow is believed to enter the mine in the vicinity of the ore body.

The AMD is acidic and contains dissolved and suspended heavy metals that have demonstrated significant aquatic toxicity. The pH is typically between 2.5 and 3.5, and the constituents of primary concern are heavy metals. Discharge rates from the mine are usually between 1,300 and 1,700 gallons per minute (gpm), but have peaked at over 6,000 gpm during precipitation and snowmelt events as a result of surface water infiltration to the mine workings. Additional mine water characterization is provided in Table 1-1 and Section 2.

As discussed in the baseline risk assessment in Section 2.5, a prolonged direct release of AMD to Bunker Creek and then to the South Fork Coeur d'Alene (SFCdA) River would result in an acutely toxic shock to the aquatic system, likely resulting in significant mortality of fish and invertebrate species. The following are the contaminants of concern (COCs) identified in the risk assessment:

- For aquatic and terrestrial receptors: aluminum, arsenic, cadmium, copper, iron, lead, manganese, mercury, selenium. silver, and zinc
- For humans: arsenic, cadmium, lead, mercury, and thallium

The AMD contains significant quantities of these COCs, much higher than in treated AMD (current CTP effluent). To put this into perspective (using zinc as an example), a 1-day release of untreated AMD is equivalent to about 1.4 years of existing CTP discharge, and about 5.6 years of discharge if the CTP was updated to achieve the TMDL and state water quality criteria.

1.3.2 Overview of the Current AMD Management System

Within the mine, the AMD flows through a series of workings and is collected in underground ditches. The lower portions of the mine are flooded, and pumps are used to keep the water level pumped down to within a specific range near 11 Level. All the AMD converges together on the 9 Level of the mine (400 feet higher than 11 Level), and is drained through the Kellogg Tunnel and out the Kellogg Tunnel portal, which is the main mine entrance. The Kellogg Tunnel, portal area, portions of the mine yard, underground workings, mineral rights, and much of the land surface above the mine is currently owned by the New Bunker Hill Mining Company, of which Mr. Robert Hopper is President.

At the portal the AMD flows into a concrete ditch, passes through a Parshall flume for flow measurement, and then enters a buried pipeline that conveys it to a lined surface impoundment (pond). The lined pond is the central collection reservoir for site waters requiring treatment. It collects the mine water, discharge from an old mine water pipeline, wash water from two vehicle decontamination stations, leachate from the smelter area principle threat material (PTM) closure, and drainage from the industrial landfill cap toe drain. The mine water flow is the largest of all these flows, on average contributing more than 90 percent of all water requiring treatment. The mine water is also the most contaminated of the site waters. On a per-gallon basis, it contains the highest concentrations of dissolved metals, requires the most treatment chemicals, and generates the most sludge. A pump station is used to pump the combined site water from the lined pond to the CTP. If not collected at the portal, the untreated AMD would flow downhill through the mine yard, across properties where public and environmental exposures would occur, and into Bunker Creek and the SFCdA River.

The CTP uses lime neutralization to remove the acidity and to precipitate the metals, which are removed by gravity settling, forming a sludge. The sludge is pumped into an unlined disposal area on top of the CIA. The treated water is discharged into Bunker Creek, which flows into the SFCdA River. The CTP was constructed by the Bunker Hill Company and has not been significantly upgraded since it started operations in 1974. The CTP is currently operated and owned by the U.S. Environmental Protection Agency (EPA). The EPA is also

NEXT

operating all mine water management systems outside the mine, consisting of the collection channel, pipeline, lined storage pond and pump station, and the sludge disposal area.

1.3.3 New CTP Discharge Levels

Table 1-2 shows the typical current discharge quality from the CTP. Table 1-3 lists the current CTP operational discharge requirements. These requirements are pursuant to an expired National Pollutant Discharge and Elimination System permit (NPDES) for the CTP.

EPA and IDEQ have developed waste load allocations for individual sources, including the CTP, for cadmium, lead, and zinc as part of the TMDL for the SFCdA River, which are described in more detail in Section 2.6. The current typical effluent quality of the CTP, listed in Table 1-2, will not meet the new TMDL-based discharge levels, which are considerably more stringent than the current requirements. The current CTP effluent will also not meet all Idaho surface water criteria, which are described in Section 2-6.

1.4 Summary of the Problem

The mine water management problem at Bunker Hill stems from the following issues of concern:

- Release of untreated AMD to Bunker Creek results in toxic aquatic conditions in the creek and in the SFCdA River.
- The magnitude of the AMD flows, and particularly the high peak flows, results in considerable expense and effort to collect, convey, store, and treat the mine water.
- AMD discharge from the mine is expected to continue indefinitely. Current technology is unable to stop the formation and discharge of AMD from the mine.
- No long-term plan exists for control and management of the mine water.
- No measures are being taken to further reduce the flow rate and contaminant load of the mine water.
- Equipment at the CTP is reaching the end of its design life or it is inefficient, resulting in high operating costs. Some of the equipment is inoperative, and much of the equipment is approaching 30 years old and needs to be replaced. These conditions increase the likelihood of unplanned CTP shutdowns and the release of untreated AMD.
- The CTP cannot produce treated water that will meet the recently finalized TMDL-based discharge levels and all Idaho surface water quality criteria.
- The remaining sludge disposal space will be filled in approximately 3 to 5 years and additional or replacement space is needed for continued operation of the CTP.

1.5 Remedial Action Objectives

The goals and objectives of this RI/FS are to present alternatives for long-term management of the mine water and to address the problems identified above in Section 1.4.

NEXT

The following are the remedial action objectives (RAOs):

- Prevent the release of untreated AMD into Bunker Creek and ultimately into the SFCdA River
- Reduce the concentrations and mass per day of metals discharged into Bunker Creek and ultimately into the SFCdA River
- Achieve the TMDL and Idaho surface water quality criteria
- Upgrade the CTP using more modern and reliable equipment to reduce unplanned shutdowns, to meet the new discharge standards, and to increase efficiency
- Provide additional sludge disposal capacity to enable ongoing operation of the CTP
- Reduce both the overall quantity of AMD generated by the mine, and the peak flows, which are the most difficult to collect and manage
- Reduce long-term AMD management costs
- Reduce the volume of sludge generated at the CTP to reduce long-term disposal costs

The alternatives developed and presented in Section 4 and evaluated in Section 5 of this report present options for meeting these objectives. The alternatives focus on managing the problem using the best, currently available technologies and approaches. New control methods and strategies may be developed in future years to further reduce or eliminate the long-term burden of managing the Bunker Hill mine water.

TABLE 1-1
Summary Characterization of the Bunker Hill Mine Water[1]
Bunker Hill Mine Water RI/FS Report

Parameter	(Units)	Average[1]	Range[1]	Average Load (lb/day)[2]
Flow	gpm	1,300 to 1,700	500 to 6,700	
pH		3.1	2.6 to 3.8	
Temperature	degrees C	14.5	10.6 to 18.0	
Conductivity	µmhos/cm	2,000	1,100 to 3,600	
Sulfate	mg/L	1,900	500 to 5,300	34,000 lb/day
TSS	mg/L	170	30 to 500	3,100 lb/day
Lime Demand	lb/1,000 gal	8.2	3.7 to 40	18,000 lb/day
Solids Formed	lb/1,000 gal	8.6	3.5 to 43	19,000 lb/day
Aluminum (total)	mg/L	6.7	2.0 to 38	120 lb/day
Antimony (total)	mg/L	0.003	0.002 to 0.009	0.05 lb/day
Arsenic (total)	mg/L	0.41	0.05 to 3.6	7.4 lb/day
Barium (total)	mg/L	0.031	0.019 to 0.059	0.56 lb/day
Beryllium (total)	mg/L	0.002	0.0006 to 0.008	0.04 lb/day
Cadmium (total)	mg/L	0.39	0.11 to 2.0	7.0 lb/day
Calcium (total)	mg/L	130	27 to 240	2,300 lb/day
Chromium (total)	mg/L	0.006	0.0005 to 0.022	0.11 lb/day
Cobalt (total)	mg/L	0.190	0.07 to 0.72	3.4 lb/day
Copper (total)	mg/L	0.52	0.11 to 3.9	9.4 lb/day
Iron (total)	mg/L	210	78 to 900	3,800 lb/day
Iron (dissolved ferrous)	mg/L	41	11 to 73	740 lb/day
Lead (total)	mg/L	0.75	0.33 to 2.5	13.5 lb/day
Magnesium (total)	mg/L	160	48 to 280	2,900 lb/day
Manganese (total)	mg/L	130	31 to 230	2,300 lb/day
Mercury (total)	mg/L	0.0001	0.00005 to 0.0003	0.002 lb/day
Nickel (total)	mg/L	0.16	0.07 to 0.47	2.9 lb/day
Potassium (total)	mg/L	5.3	0.99 to 11.2	95 lb/day
Selenium (total)	mg/L	0.02	0.001 to 0.055	0.36 lb/day
Silver (total)	mg/L	0.02	0.002 to 0.052	0.36 lb/day
Sodium (total)	mg/L	2.4	0.005 to 7.0	43 lb/day
Thallium (total)	mg/L	0.030	0.001 to 0.084	0.54 lb/day
Vanadium (total)	mg/L	0.003	0.0005 to 0.025	0.05 lb/day
Zinc (total)	mg/L	170	63 to 700	3,100 lb/day

[1]Chemistry is based on Kellogg Tunnel discharge monitoring data collected during the 1998/1999 monitoring program. Flow is based on historical data between 1972 and 1999.

[2]The daily load is calculated using an average flow of 1,500 gpm and the Average concentrations.

NEXT

TABLE 1-2
Typical Current Central Treatment Plant Discharge Quality
Bunker Hill Mine Water RI/FS Report

Parameter	(Units)	Typical Average[1]
pH		8 to 9
Cadmium (total)	µg/L	3.0
Lead (total)	µg/L	100
Zinc (total)	µg/L	240
Total Suspended Solids	mg/L	<1 to 4

[1]From a review of the April 1999 through March 2000 discharge monitoring reports.

TABLE 1-3
Current Central Treatment Plant Operational Discharge Requirements
Bunker Hill Mine Water RI/FS Report

	Daily Average Limit[a]		Daily Maximum Limit[b]	
Parameter	**µg/L**	**lb/day**	**µg/L**	**lb/day**
pH (pH units)	The pH must be between 6.0 and 10.0			
Total Suspended Solids	20,000	985	30,000	1,907
Total Zinc	730	36.2	1,480	91.3
Total Lead	300	14.8	600	37.0
Total Cadmium	50	2.4	100	6.1
Total Copper[c]	150	7.4	300	18.6
Total Mercury[c]	1	0.05	2	0.12

[a] The total units discharged during a month divided by the number of days the plant operated that month.
[b] The maximum value attained on any day in a given monitoring month.
[c] Daily monitoring for copper and mercury not required.